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WOOD WASTE INCINERATION

M. Popovich, et al

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

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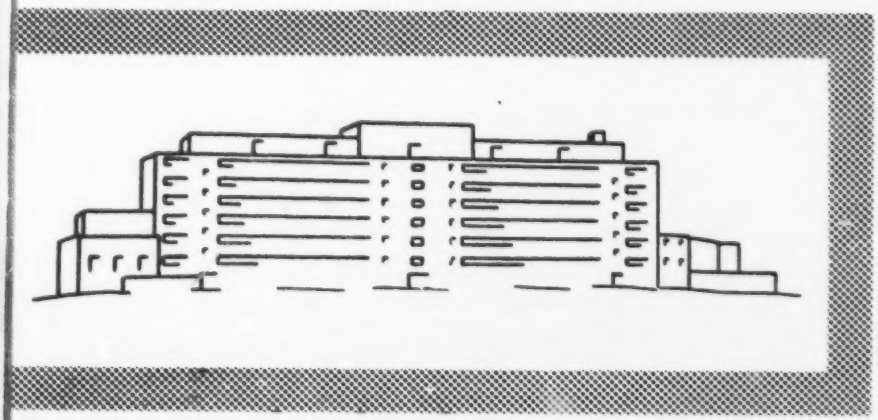

The Robert A. Taft
Sanitary Engineering Center

TECHNICAL REPORT

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U. S. DEPARTMENT OF HEALTH,
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WOOD WASTE INCINERATION

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Details of illustrations in this document may be better studied on microfiche

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Bureau of State Services
Division of Air Pollution

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FOREWORD

In an effort to reduce smoke and cinders discharged to the atmosphere from tepee type wood waste burners, the Engineering Experiment Station at Oregon State College conducted a study of burning practices and the emissions resulting from these incinerators. The study had the support and cooperation of the U. S. Public Health Service (Project Grant A-57-941) under the direction of the Engineering Research and Development Section of the Laboratory of Engineering and Physical Sciences, Division of Air Pollution, and the Oregon State Sanitary Authority, as well as many individuals and organizations within the lumber industry.

A detailed report covering all aspects of the study has been published as Bulletin No. 39 of the Oregon State College Engineering Experiment Station. The present paper is a condensation of the original report.

Trade names are mentioned in this report for identification only, and their use does not signify endorsement by the Public Health Service of the proprietary products represented.

WOOD WASTE INCINERATION

In the manufacture of lumber in most sawmills, approximately 50 percent of the log becomes waste material in the form of sawdust, shavings, bark, and coarse residue. Although many useful by-products have resulted from utilization of wood wastes, millions of pounds of wood are burned daily in incinerators of mills where complete utilization is not economically feasible. The most widely used type of incinerator is the tepee-shaped, single-walled, steel waste burner pictured in Figure 1.

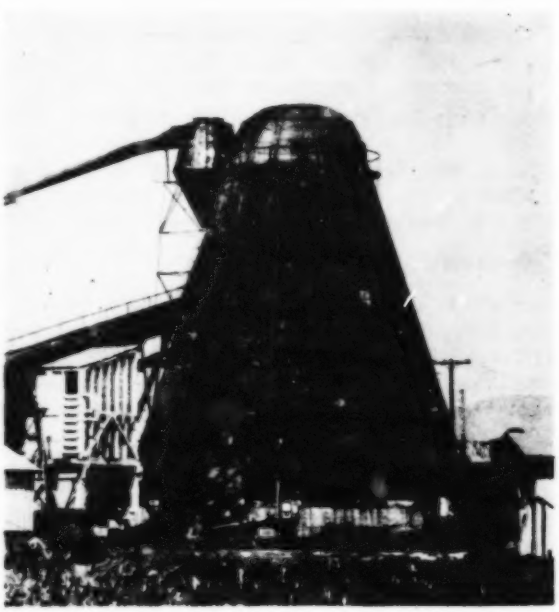

Figure 1. TYPICAL WOOD WASTE INCINERATOR.

Tepee-type waste burners at some operations have done a creditable job in consuming waste products with only a minimum discharge of smoke and cinders. At most operations, however, the great quantities of smoke and cinders produced have caused hazardous visibility conditions for automobile and air travel, and have created a nuisance and fire hazard to property owners in surrounding areas. Fallout of cinders has been measured in daily tons per square mile in many areas.

Multiple chamber refractory-lined incinerators have not found general use in wood waste incineration because of relatively high cost of construction. Although this type of incinerator is considered efficient for many applications, it is not ideal for the burning of very light bulky materials having large particle size and requiring several seconds to burn. The particles tend to be carried through the incinerator by the draft and discharged from the stack. An effective cinder collector will reduce materially the discharge of unburned particles, but such a device adds to the expense of the installation.

A study of wood waste incinerators was initiated at Oregon State College in June 1957, under an Air Pollution Demonstration Grant of the Public Health Service. It was directed toward determining why certain steel tepee-type burners operated with a minimum of smoke and cinder discharge. It was considered that development of design criteria for construction and directions for the successful operation and control of such inexpensive burners would indeed aid in the reduction of air pollution. Most mill operators can well afford a properly designed, simple, steel incinerator, but a great many could not remain in business if required to construct a relatively elaborate refractory type.

Test Approach

The objective of the test program was to study the effects of variables in burner operation and design upon smoke and cinder discharge. During the first part of the program, the operation was studied of eight typical waste burners in normal millsite operation. In the second part, a model of approximately one-third average size was studied under closely controlled conditions. Both parts of the testing program led to the same general conclusions for the improvement of design and operation.

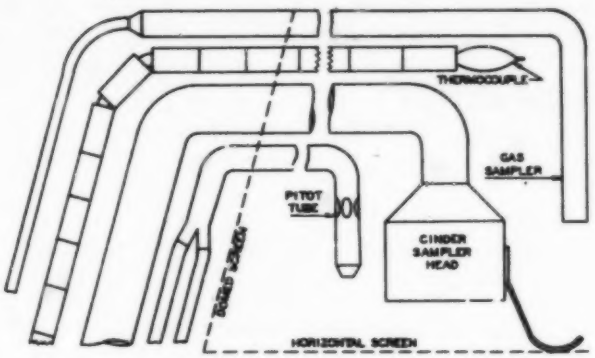

Figure 2. SCHEMATIC DIAGRAM OF SAMPLING AND SENSING INSTRUMENTS.

Measurements made during field tests of full-scale burners included the following:

1. Exit gas temperature
2. Exit gas analysis
3. Exit gas velocity
4. Burner draft at base
5. Smoke density (visual)
6. Cinder discharge

Additional data taken during tests of the model burner included quantity of underfire air, shell temperature at 11 locations, and rate of fuel feed. In the field tests, rate of fuel feed was calculated by carbon balance from ultimate analysis and moisture content of the fuel and data items 1, 2, and 3 above. Smoke density observations were made visually because it was found difficult to assign Ringelmann values to wood smoke. Smoke density standards were prepared from photographs of conditions described as "no smoke," "light smoke," "medium smoke," and "heavy smoke."

A 1-inch (inlet size) Aerotec dust collector, connected by piping to a 2-7/8 inch diameter sampling head located above the horizontal screen in the burner, was used for obtaining the rate of cinder discharge. Filter bags inside the Aerotec dust collector were replaced by cups made from 50-mesh brass screen to avoid plugging by moist cinders. Cinder discharge figures obtained, therefore, related to particles greater than approximately 250 microns in diameter. Suction through the Aerotec collector was adjusted so that velocity of gases entering the sampling head was equal to the velocity of exit gases. Figure 2 shows schematically the sampling and sensing devices installed in the top of each incinerator tested. Measuring instruments are shown in Figure 3. The model burner (15-foot) is illustrated in Figure 4.

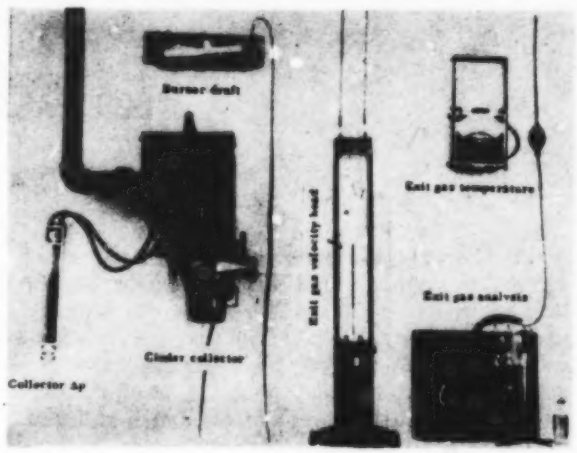

Figure 3. MEASURING INSTRUMENTS

The overfire air inlets on the model burner were designed so that air would be drawn into the burner tangentially. Sliding covers were made so that some control could be exercised over the quantity of air for combustion (Figure 5). Air inlet covers were removed to determine the effect on cinder discharge of bringing the air into the burner radially. The blower for supplying underfire air to the model burner is shown in Figure 6. The nozzle at the blower entry was used for air quantity measurement.

Test Results

Figure 7 illustrates field test data assembled from the operation of a properly designed and operated burner. Exit gas temperature was maintained above 400 F, and the stack remained clear except for a short period when feed to the burner was reduced and the temperature dropped. Total cinder discharge for the day's operation was measured at 15 pounds. This result may be compared to field test data (Figure 8) from a burner of the same size burning the same amount of waste, which discharged 600 pounds of cinders over a similar period of time. The latter burner did not have tangential overfire air inlets. Air was introduced radially through openings near the bottom of the shell. The poorest result was obtained from a burner having radial air openings and many gaping holes all over the shell. It discharged 2700 pounds of cinders in one day, along with copious amounts of dense black smoke. The test log is shown in Figure 9.

Burners discharging low quantities of cinders and little smoke possessed certain common characteristics. They were designed with tangential overfire air inlets, and were in good

Figure 4. MODEL INCINERATOR

Figure 5. TANGENTIAL PORTS AND SLIDING COVERS.

Figure 6. UNDERFIRE BLOWER FOR MODEL INCINERATOR.

physical condition without gaps between plates. From the operating standpoint, fuel feed was reasonably constant, and sufficient fuel was being burned to maintain high exit gas temperatures.

Figure 10 was developed from a composite of the smoke observations and the excess air measurements made during field tests. The results definitely indicate that maintaining the excess air below 300 to 400 percent will virtually insure smoke-free operation. Such operation means that exit gas temperatures are to be in the range of 600 F to 1000 F. However, in order that cinder discharge be low, it is essential that overfire air enter tangentially to provide a cyclonic action within the burner. This action provided turbulence for good mixing and kept suspended particles in the combustion zone for a much longer period of time by reducing short circuiting which could occur when combustion air was not introduced tangentially.

Introduction of air under the fuel bed through grates materially assisted the combustion process. Experimentation with the model burner indicated that the quantity of underfire air should be from 10 to 35 percent of the total combustion air, depending upon the moisture content of the wood. Dry wood apparently requires little underfire air, while moist wood requires the larger quantity.

Size-capacity recommendations of wood waste burner manufacturers were examined in the light of field and model tests over a size range from 15 feet in diameter and height to 80 feet in diameter and height. Figure 11 indicates that a composite of manufacturers' recommendations was reasonably accurate, although an 80-foot burner operated very well at considerably above the waste input rate in units of waste (approximately 2000 pounds, dry) indicated by manufacturers. A burner of proper size is of prime importance for the efficient disposal of wood waste because an undersized burner will become overheated and damaged structurally. An oversized burner will operate at low temperature with high excess air, although air openings may be designed to provide some control of overfire air.

Design recommendations for wood waste incinerators on the basis of Oregon State College studies are as follows:

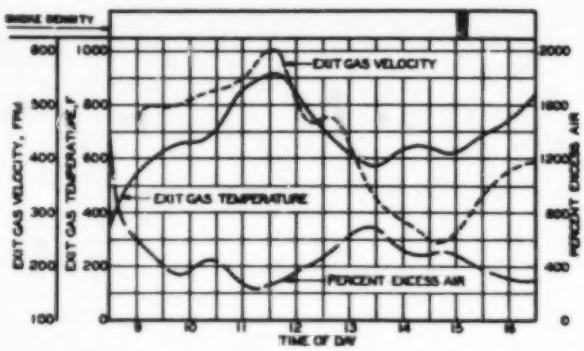

Figure 7. FIELD TEST DATA EXHIBITING SATISFACTORY OPERATION.

NOTE: Smoke densities in Figures 7, 8, and 9 are as indicated in Figure 10.

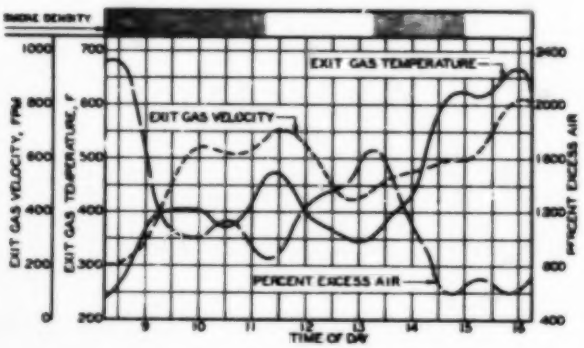

Figure 8. FIELD TEST DATA EXHIBITING UNSATISFACTORY OPERATION.

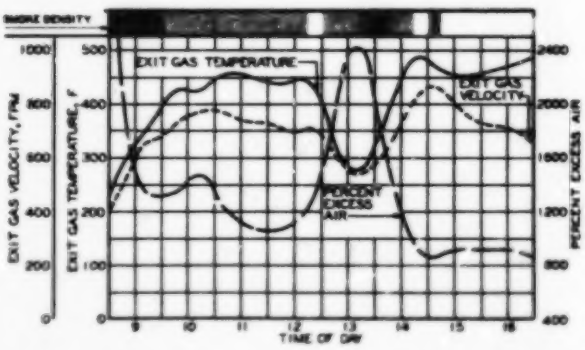

Figure 9. FIELD TEST DATA EXHIBITING VERY OBJECTIONABLE OPERATION.

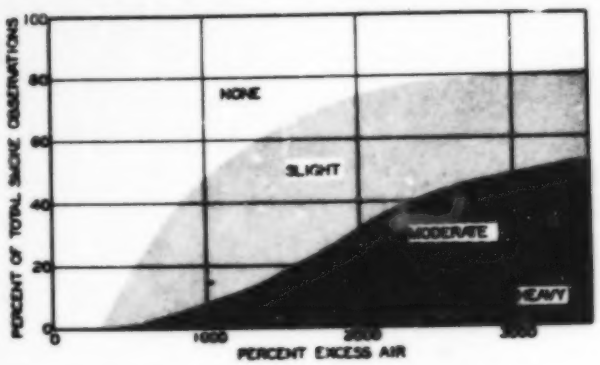

Figure 10. EXCESS AIR-SMOKING CORRELATION.

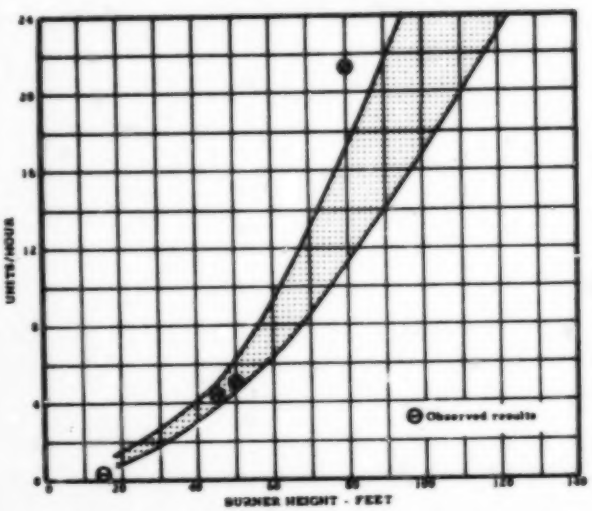

Figure 11. BURNER SIZE - CAPACITY CORRELATION.

1. The configuration of the shell resembles a tepee or truncated cone, with height approximately equal to the base diameter, and top diameter 40 to 50 percent of base diameter. This shape provides combustion chamber volume necessary for burning wood, and is simple to construct.

2. Underfire air, from 10 to 35 percent of total air supplied, is introduced through horizontal or conical grates by a centrifugal blower with backward curved blades. For burning dry shavings or sawdust, the lower limit of underfire air should be used. For wood having 50 percent moisture content, the upper limit should be available.

3. Overfire air is introduced tangentially to burner shell through hooded ports located at the base of the burner. The opening of ports should be sized so that excess air will be approximately 200 percent at the maximum waste input rate. Adjustable covers should be made for the hooded parts so that overfire air may be manually controlled.

4. Conveyor opening is as small as possible consistent with size of material being fed to the burner to avoid reduction of draft and effectiveness of cyclonic combustion.

5. To operate at the high temperature necessary for clean burning, it is imperative to design the burner so that structural members are on the outside and the shell is on the inside.

6. In order for the properly designed burner to function properly, fuel must be supplied to the burner at a reasonably uniform rate. Excess air must be maintained between limits of 200 and 400 percent. For this range the exit gas temperatures will be approximately 900 F to 600 F. The placement of a protected chromel-alumel thermocouple at a point about one-third across the diameter a few inches below the horizontal screen at the top of the burner will provide the control information necessary.

7. Extremely fine feed should be mixed with the coarser feed and not dumped in concentrated quantities. Sander dust requires special handling; the tepee-type burner will burn it smokelessly if it is a relatively minor constituent of the waste feed, and if it is properly introduced.

8. When the moisture content of wood exceeds 50 percent (on the wet basis), the wood becomes difficult to burn in any kind of furnace or incinerator. In locations where smoke and cinder discharge from burners must be maintained at a low level, it may be necessary to supply cylinder oxygen to a smoldering fuel pile to accelerate burning to the level at which it will be self-sustaining. Acceleration of the burning of wet wood might also be accomplished by intermittent use of a butane or oil burner.

The size of the incinerator may be approximated from the equation

$$D = 2.3\,Q^{1/3}$$

where

D = diameter of base = height, in ft

Q = quantity of waste to be burned, lb per hour.